AN EXPERIMENTAL INVESTIGATION OF THE PHENOMENON OF POSTURAL PERSISTENCE

BY
LOWELL SINN SELLING, M.D.

L. C.

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, in the faculty of Philosophy, Columbia University.

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An Experimental Investigation of the Phenomenon of Postural Persistence

PART I

Historical Introduction

The phenomenon of persistence of posture has been described by Hoff and Schilder (5) and consists of the following features:

"If a person holding his two arms horizontally before him raises one arm to about forty-five degrees above the horizontal and holds it in this position for about thirty seconds, and, if he, then, follows instructions to close his eyes and to bring the raised arm to the same position as the other, the horizontal one, in the case of all normal persons the arm will not go back to the horizontal position but to a position nearer to the previous raised one. This is not a persistence of muscular tension because if the arm is lowered to a level below the horizontal and is kept there about thirty seconds again, then, after the order is given to bring this lower arm to the same position as the other, the horizontal one, the subject will not bring the lower arm as high as the horizontal."

Hoff and Schilder (5) have found that in a number of cases of Parkinson's Syndrome, this phenomenon is absent and there was also a case of a lesion of the diencephalon and midbrain in which there was a marked deficiency in the persistence of posture. Schilder and Stengel (13) found in a case of Tabes Dorsalis, the upper extremities of which were practically in order and did not show any changes in sensation, that the subject was deficient in the persistence of posture. The autopsy of this case revealed that there were changes in the spinal cord and lesions in the mid-parts of both globus pallida. In cerebellar cases the postural persistence is always present and seems even to be increased and, too, postural persistence can be found in cases where there are serious deficiencies in sensation. Hoff and Schilder (6) show that the phenomenon of postural persistence is present during hypnosis and is not affected by the destruction of the labyrinths.

The phenomenon exists, according to these investigators,

in every normal individual and Eidelberg (1) also has found this to be true. The phenomenon is present on both the right and left sides either when the arm is raised or when it is depressed. The phenomenon is one which can be provoked in every attitude of the body, but from the clinical point of view only the persistence of posture in the shoulder has been investigated. Eidelberg has studied some features of the phenomenon in a quantitative way. He has shown that the time of exposure, that is, the time during which the arm is held away from the horizontal, is of some importance but he does not give the exact data to show the time necessary to elicit the reaction or the effect of time upon the reaction, indicating only that the reaction after thirty seconds is greater than after five seconds. Even if the arms are lowered to the sides between the exposure and the resumption of the final horizontal posture, the persistence of posture is still present. Eidelberg says the phenomenon disappears after sixty seconds as a general rule but that the reaction is strongest immediately after the exposure, and also shows that the phenomenon is present regardless of whether the subject keeps his arm actively in the position which is adopted during the exposure or whether the arms are passively supported in that position. It has been shown, too, that it does not matter whether the subject has his eyes open or not during the period of exposure.

Hans Strauss (15), however, states that, though he finds the postural persistence in every normal individual, he does not find it present if the arms are supported. This is undoubtedly erroneous, although Eidelberg's findings are that the active performance of the experiment is more efficient than the passive. He finds, in considering the efficiency of the angles in which the arm is held during exposure, in producing the phenomenon, that an angle of sixty degrees below horizontal is more efficient than an angle of either thirty degrees or ninety degrees. Hoff and Schilder (5) show that the persistence of posture is present, too, when the arms are not held originally in a horizontal position and also, when one arm is held higher or lower than the other. The phenomenon is present when the individual brings one hand back to the horizontal without the other hand being held in the air. Hoff and Schilder (6) have studied the course of the phenomenon as regards the movements of the hand from the time that the exposure is ended until the arm reaches the normal horizontal position,

and find that the persistence of posture does not disappear immediately and that while it is disappearing there is not an equal decrease of the persistence but that the difference between the two hands disappears in waves, the phenomenon increasing and decreasing rhythmically, each time bringing the arm which has been deviated from the horizontal closer to it.

The experiment can be performed in a different way. After the exposure, the arm can be returned to the exact height of the horizontal arm by means of visual clues. If the arm had been lowered during the course of the experiment it will tend to sink when the subject closes his eyes. If the arm had been raised it would tend to rise upon closure of the eyes.

The above were the facts which led Hoff and Schilder (4) to the following conclusions: First, the phenomenon is not due to persistence of muscular tension and innervation. If it were muscular tension, the postural experiment with the lowered arm would have led also to the raising of the arm above the horizontal because in this position, as well as when the arm is raised, the deltoid muscle restrains the arm against the action of gravity. On the other hand, the experiment is also present when the muscles are completely relaxed, i.e., the arms supported, an additional argument against muscular tone being the important factor. Persistence of the muscular innervation is very well understood and it is illustrated by the so-called Kohnstamm phenomenon. When, in this experiment, the arm is pressed against an obstacle for a period of time and the obstacle is removed, the arm tends to move in the direction in which the tension of the muscles had been previously exerted, even against the will of the subject. When in the Kohnstamm experiment the arm is below horizontal and the action is exerted upward there is observed a rising of the arm above horizontal and this is the opposite to the observations in the case of the experiment of the persistence of posture. This shows that the phenomenon which was studied by Schilder and Hoff is not due to the persistence of innervation. It is also remarkable that, whereas postural persistence is often absent in Parkinsonian cases, the Kohnstamm phenomenon is always positive, and even increased.

The second conclusion of Schilder and Hoff is that the persistence of posture has nothing to do with errors in judgment. In other words, this type of error has no relation to

the kinaesthetic experiments of Judd (7), of Spencer (14) and of Warden (16) which show that judgment errors exist in both directions when kinaesthetic sensation supplies the required information. An additional argument against this is the fact that when an individual puts his hands at a horizontal level after exposure to an angle with his eyes open, upon closing his eyes the exposed arm will be drawn in the direction of the previous exposure away from the horizontal. These experimenters come to the conclusion that the raising and lowering of the arm provokes a motor tendency toward the resumption of the previous posture; that although the change in the tonus does not come to consciousness the final posture of the arm is a compromise between the posture which was intended and the posture induced by the exposure. They consider the phenomenon as an unconscious one, apparently a special case of sensory adaptation, and that every posture influences a central apparatus in a centripetal manner and this effect remains for a period of time to be expressed in the next movement.

There exists not only a persistence of motor innervation as shown by G. E. Mueller and Schumann (10) and persistence of sensory innervation, but also a persistence of postural attitude.

Hoff and Schilder (5) point to the fact that the subjects do not know anything about any of these changes in their tonus and that the phenomenon has nothing to do with the conscious impression and judgment about the posture and must be based on some lower somatic mechanism.

Since the phenomenon is outside of consciousness, the individual is not aware, in spite of his remaining kinaesthetic and tactile impressions, of what is going on, and he considers the posture of the limb as normal even though it shows the unconscious increase of tone in the direction of its previous position. The individual feels that the arm raised or lowered by postural persistence is horizontal and his knowledge concerning his own body or the position of parts of his own body is changed by the abnormal muscular tone. The experiment shows, therefore, that the subject's knowledge and judgment concerning his own body is dependent, at least in part, upon his musuclar tone, and his musuclar tone is dependent on whatever previous postures he has assumed. These authors consider that postural persistence is part of the large apparatus which

regulates the postural attitudes and this, accordingly, brings the phenomenon in close relation to the posture and righting reflexes describd by Magnus and DeKleijn (8) and studied in humans by Goldstein (3), Riese (11), Mittelmann (9), Fischer (2) and Zingerle (17). They point to the fact that Parkinsonian cases, although there are no changes in judgment and sensation, are the only cases, except those of midbrain and diencephalon lesions, in which the persistence of posture is absent. This fact is another bit of evidence against the interpretation of the persistence-of-posture experiment being a result of bad judgment.

Apparently lesions of the strio-pallida-substantia nigra system cause, in addition to a loss of other postural and righting activities, a loss of persistence of posture. The postural persistence experiment, accordingly, indicates how many factors of the purely somatic and probably subcortical type underlie motor actions and the knowledge of the position of our limbs. This experiment shows, too, that our judgment concerning the posture of our own body is to some extent dependent upon postural tonic influences, and this should be of interest to the psychologist since only by the investigation of such somatic phenomena is it possible to separate these from the purely psychic or higher factors in our actions.

As noted in the Introduction, preliminary studies of several factors which inflence the phenomenon of "Persistence of Posture" have been made. However, a number of other important aspects remain to be investigated, and even those that have been studied in a preliminary way require more thorough going and quantitative experimentation.

The aim of the present study was, (1) to determine the effect of different intervals of exposure time on the phenomenon, (2) to compare the amount of deviation in the two sexes, (3) to compare the amount of deviation in the left and right arms in both the upward and downward movement, and (4) to determine the influence of age upon the phenomenon. A description of the several groups employed in the investigation will be given in the following section.

PART II

Method and Procedure

Apparatus

The apparatus for this experiment is comparatively simple. The method used by previous workers in measuring the difference between levels of the two hands was merely holding a chart divided in centimeters next to the hands and reading the difference between the two. Obviously this was inexact because the chart could not be held at any definite angle in regard to the position of the hands and in regard to the position of the horizon. It was necessary, therefore, to devise a method to show approximation between the two hands which would permit as small an error as possible arising from angular differences in the readings.

The instrument (Plate I) devised consisted of a stand constructed of a perpendicular pole resting on a flat base and reinforced so that a sliding collar could be fastened upon it. Upon the sliding collar was a scale adjusted to be perpendicular to the ground which could be moved up or down, depending on the height of the individual to be tested. While this apparatus might have been used without the sliding collar in testing adults, the range of the metric rule being two meters, the sliding device was of marked assistance in adapting the instrument to the measurement of children.

Procedure

In using this apparatus the following method was adopted with adults:

1. The individual was in no way warned as to the elements in the test. He was merely prepared by assuaging his fears, telling him that it was not a mental test and that he was merely to do what he was told and by doing so he would be assisting in the preparation of scientific data. He was told that certain measurements were to be made; that the results were not standardized and that no judgment could be made as to whether he was normal or not. We requested that he pay attention to instructions and make an earnest effort to carry out the performance required.

2. He was shown the apparatus and instructions were given him to raise both his arms to shoulder height. Then the experimenter stated that he was going to elevate or depress one of the arms holding it at an angle of approximately forty-five degrees to the other arm, supporting at the same time as well the arm which was not moved. He was warned that the experimenter would tell him at the appropriate time to raise or lower the hand as the case might be so that both hands would be parallel to the ground,—in other words, to assume the original position.

3. The performance of the experiment was gone through once or twice in each quadrant which would be used so that the individual would understand the method of carrying out the experiment and so that the final command, to make his hands parallel, would not be misunderstood. If the subject seemed bewildered the performance of the various acts required would be demonstrated by the experimenter so that the subject could see exactly what was to be done.

4. Until this point the whole of the performance was carried out with the eyes open. Because the eyes were open the subject was unaware of the relative difference in position of the two hands which would occur when the eyes would be closed, since he was able to correct the deviation through visual sources. In fact, after the experiment was completed, when the subject was shown the existence of this phenomenon, he was very much surprised, which indicates that going through the preliminary experiment with the eyes open does not give the subject insight into the deviation between the two hands.

The subject was blindfolded and instructed to raise his hands in front, parallel to the ground as he did before. When this was done the apparatus was placed between the two hands so that the scale on each side approximated the tip of the index finger corresponding to it, i.e., so that the finger nail would act as a pointer against the subdivisions of the metric scale. The scale was then lowered or raised so that there would be plenty of space on it available to record the deviation. For instance., if the left arm were to be depressed, the experiment could be begun at the zero point of the scale at the top, the finger nails of the index fingers of both hands resting at the level of the zero point but not against the scale. The deviation, of course, was downward because of the initial deflection being downward. Hence all positive readings would

fall upon the scale. When the variable arm was raised the scale was reversed so that the zero point would fall at the bottom, thus enabling the larger part of the scale to be above the starting point, so the deviations above horizontal could be measured. After adjusting the instrument the subject was instructed to drop his arms and rest.

5. Each individual test was carried out as follows:

The instructions were given: "Raise both arms," (Plate II) and, upon this being carried out, measurements were taken to see the relationship of both hands. Then the two hands were grasped lightly by the experimenter and the variable hand raised or lowered as the case might be (Plate III), simultaneously starting the stopwatch. After the appropriate time interval had passed the hands were released and the order was given, "Now make your hands parallel," (Plate IV) and, as soon as the motion of the two hands had stopped, readings were again taken on both hands. When this was completed the order, "Rest," was given and the subject dropped his hands. The subject then rested for an interval varying from 5 to 20 seconds, according to the length of time that his hands had been held up during the experiment. The method in the case of the children had to be modified slightly, particularly with the younger ones. In regard to these, it was necessary to make the experiment somewhat in the nature of a game, numbering the procedure: "one," raising the hands to horizontal; "two," the depression of the hands by the observer; "three," the spontaneous resumption of the horizontal position. Sometimes a drill resembling the military was gone through in training the children how to bring the hand back to horizontal. Even after having taught them to perform the act with the eyes open, when the children were blindfolded the performance of the experiment had to be gone through passively in some cases. Also in the case of the children the rest period was longer. Rests of as long as thirty seconds to one minute were necessary between the experiments even when the arm was deflected for only five or ten seconds.

The Collection of Data

On each individual measurements were taken for seven time intervals, those which were considered to be the most significant being the ones adopted. After preliminary trials, it was found that the time intervals that showed the maximum

PLATE I
Instrument—Front View.

PLATE II
Starting Position for all Tests.

PLATE III
Left Hand Depressed During Time Interval.

PLATE IV

Final Position of Hands in Either Left Arm Depressed or Right Arm Raised.

readable variations were: 1 second, 3 seconds, 5 seconds, 10 seconds, 20 seconds, 35 seconds and 45 seconds. Hence, these were used in each of the four possible relationships. By this we mean that when the arms are held horizontally in front of the body it is possible to deflect each arm both upward and downward, and therefore measurements could be taken in the two right and two left quadrants. In each case the arm was deflected either upward or downward for the seven time intervals, giving one series of measurements of consecutively increasing time period in each of the four possible quadrants.

This method was superior to previous methods of studying the phenomenon in that the position assumed in the test permitted the hands, when raised horizontally, to be brought close to the scale so that accurate measurements could be made. The scale itself was placed perpendicular to the ground so that all angular deviations, so far as the scale is concerned, were avoided. Although Schilder and Hoff (4) measured the deviation in units of two centimeters, it was thought best to use a finer measure in the present study. Accordingly, the unit of deviation adopted was one centimeter. Inasmuch as the extended hands tend to fluctuate somewhat, this was considered to be as fine a measure of deviation as could be made with any degree of accuracy. The general experimental conditions, such as room temperature, avoidance of distractions, etc., were favorable. This procedure was developed into a routine which was carried out completely for all times and all four quadrants, alternately right and left and beginning with the shortest time first. At another period in the day the routine was again carried out, but beginning with the last tested quadrant and running through to the first again, alternately left and right and beginning with the longest time interval. This gave two complete readings at each time for each quadrant in each individual and these two readings were averaged to give a single result. The data obtained from these experiments in each group were arranged in frequency tables. Along the abscissae of these tables was placed the time interval. Along the ordinates was placed the amount of deviation. The tables themselves show the frequencies of deviation occurring at a given time expressed in the number of cases. The average for each period of time was obtained by multiplying the deviation by the frequencies and dividing by the number of cases. The averages were then charted on a mimeograph

sheet so as to be more easily understood. The deviations were then converted into expressions of the angle which the arm varied from its horizontal when reaching its final resting place. The angle was determined by finding its sine, and in computing the latter, the arm length was considered the hypothenuse and the reading on the scale the known side. The final index was expressed in degrees and minutes, since the use of finer measures (seconds) did not appear to be warranted under the circumstances. Standardized arm lengths were obtained based on averages for the two sexes, which were as follows:

Ages	*Males*	*Females*
4-7	49	48
10-14	60	58
Adults	72	69

Possible Sources of Error

The main possible source of error lay in the difficulty of reading the scale accurately. However, the subject's fingers were required to be brought close to the scale in all cases so that errors from this source were eliminated as far as possible. Furthermore, a large amount of practice in preliminary work tended to cut down inaccuracy. Since the unit of deviation was the centimeter, it seems unlikely that inaccuracies that would affect the score significantly arose from reading the scale.

The attitude of the subject toward the experiment was, of course, important. Fatigue and fright were avoided as much as possible by preliminary instructions. On the other hand, knowledge of results had to be kept from the subject, since it has been shown by previous workers that the subject tends to make correction when the direction of error in deviation is known. It was considered unnecessary to remove the clothing in taking the measurements, since it was found in preliminary experiments that this factor made little or no difference. The tests were made with the arms extended in front as a matter of convenience, although in preliminary tests it had been shown that whether the arms were extended in the front or side position made little differences.

Subjects

Eight groups were used: Two groups of children from four to eight, two groups of children from ten to fourteen, two

groups of adults from eighteen to twenty-three, and two groups of adults from forty-five and over. In each of these two groups one was composed of females and the other of males. In the groups of the younger children there were seven boys and nine girls. These were obtained from the Children's Ward of Bellevue Hospital, were up and about, were considered to be perfectly healthy and were not supposed to show any signs of mental deficiency or mental abnormality. The groups between ten and fourteen were obtained from the same source. A short application of the Stanford Revision was given to ascertain the fact that they were not defective, and there were fifteen boys and fifteen girls in each of the two groups. The two groups of young adults which were the basic groups of these experiments were made up of nurses obtained from the Training Schools of Bellevue Hospital. Each group was homogenus, the females coming from the female Training School, and the male nurses from the Mills Training School.

The female group were students and graduate nurses, and an analysis of the constituent individuals showed that the levels of intelligence were about the same, the more stupid having been weeded out through the probationary period. The educational standards were about the same, since there happened to be no college graduates although all were high school graduates. The standards of general health were high because of the consistent annual physical examination, with its higher requirements for the type of work which these young women were doing, which insured the elimination of a number of physical defects which might be found in a similar group of young girls such as college students.

In the case of male nurses the age level of the group tended to run a year or so less than that of the female group but, obviously, factors such as health, education and superficial estimate of intelligence as shown by their general aptitude for work was fairly consistent in this group, and coordinated well with the equivalent female group. There were twenty-four male nurses and twenty-four female nurses tested.

The two groups of individuals over forty-five were composed of, first, in the case of the females, fifteen graduate Bellevue nurses of over forty-five years of age, but none over fifty-five. These were all active and on duty about the wards of the Hospital. Since, at the time these women were grad-

uated the educational standards were not as high as they were in the group from eighteen to twenty-three, still the effect of this would be largely nullified by the eliminating action of time so that the individuals who were not as quick and as intelligent would have been dropped from the hospital rolls. Second, in the case of the males, the fifteen elderly men obtained consisted of a few male nurses, six in number, and nine policemen who were on duty at the hospital. This group is again comparable with the younger group of male nurses, although it is unlikely that the policemen are as intelligent and as well educated as the nurses; still the profession from which they come is sufficiently closely related to permit valid comparison.

PART III

Results and Discussion

The results of this experiment, covering 6,944 measurements on 124 individuals have been brought together in tables 1-32 which will be found in the appendix. Each table of this series represents the data on one group for a single quadrant. The following table shows the reliability of the group scores as based on these tables:

Ages	*Males*		*Females*	
	r	P.E.	r	P.E.
4—7	.58	.02	.44	.02
10—14	.71	.013	.78	.009
18—23	.77	.003	.81	.003
45 plus	.73	.013	.75	.011

It is obvious by inspection of the tables that the time curves and the amount of deviation in each quadrant are comparatively constant features. It is necessary nevertheless to determine as far as possible the reliability of the eight groups to be used. Since each point on each curve has a separate average and a gross average for the whole group would be of no significance, the usual method of plotting the frequencies and determining the reliability in terms of probable errors and standard deviations, can not be used. Instead of these it was necessary to use some method which will indicate the reliability of these groups as a whole. To do this the coefficient of correlation of the second measurements against the first was used (r_{12}). This shows reliability in terms of the closeness that the first measurement, at each point in time and in each quadrant, bears to the second measurement under the same conditions in each group. While the correlations are only fairly high in some cases, they are highly reliable, as may be seen by an inspection of the probable error as indicated above.

In tables 1—32 the columns are the deviations grouped according to the time of exposure, each successive figure downward representing the number of cases having a deviation one centimeter greater than the one above it. The horizontal readings of these tables express the same number of centimeters' deviation for successive time intervals; the horizontal line at the top showing the number of cases having zero de-

viations at the various time intervals, the lowermost line in each table expressing the maximum deviation found in the whole group, and the other lines showing the various frequencies between. The sum of each perpendicular column is the same as the number of individuals in the group, each individual having been exposed to all of the time intervals.

Although it is obvious that all of the four tables for any group (representing the four quadrants) will have the same totals in all of the columns, their values are, of course, different because the zero deviations do not enter in the average and other readings, although expressed in the number of individuals having a given reading, change the total, inasmuch as each of these frequencies must be weighted by the amount of deviation in order to express the average deviation.

The order of these tables is first of all according to sex; the first sixteen tables being those of males and the last sixteen females. Each consecutive four tables represent the four quadrants of each specific age group and the age groups are also arranged progressively, the young children first and the adults over forty-five last.

The influence of the various factors investigated are most clearly shown in tables 33-40, in which the results have been combined, and in the accompanying graphs. In the combined tables, all other factors have been ignored in order to bring out the influence of each of the four main conditions investigated: length of exposure time, sex, quadrant and age. These factors will now be discussed in the order listed.

The Effect of Time

Individual cases in all the groups show fairly representative time curves, for while the onset may be sooner or later in one case than in another and the maximums of any two curves do not occur at the same time interval in all the cases and there are occasional instances where individual measurements fall below the preceding ones, analysis of the individual results shows that out of 496 time curves 454 followed one of the typical curves expressed on following page.

In the last two instances it may be seen that the curves drop off rather suddenly. This is undoubtedly due to the fact that the time intervals and method of measuring are comparatively gross, but it does not detract from the fact that a definite time curve can be seen in practically all of the cases. The 42

TABLE XXXIII

Type	*1*	*3*	*5*	*10*	*20*	*35*	*45*	*Cases*
I	1	1	2	2	3	2	1	132
II	1	2	3	4	3	2	1	107
III	1	1	2	3	2	1	1	84
IV	1	2	3	4	4	0	0	75
V	1	2	3	3	2	0	0	56

instances which do not show a typical time curve are all flat curves, that is, the effect of time does not seem to influence the results. There were no inverted curves, however, wherein the early measurements were higher than the later ones and a minimum was found between the time intervals of 10 and 35 seconds where a maximum would be expected.

Studying the time curves in the various groups we get the following relationships of maximums, and the general influence of time beginning at the earliest point of exposure and increasing to 20 to 35 seconds can be seen in all of the curves of the individual groups. (Curves I to VIII.)

The second source of information as to the effect of time lies in the basic tables themselves. It can be seen by inspecting tables such as IX to XII and XXV to XXVIII, that there is a marked effect on the results due to lengthening the time of exposure. This can be seen to manifest itself in three ways: the changes in the number of zero deviations in each exposure, the location of the mode and its change with the change in time of exposure, and lastly, the size of the maximum deviation. In table IX for instance, it can be seen that the zero readings tend to increase markedly after twenty seconds exposure. In table XI this is even more effectually shown, for not only do the number of zero readings increase after twenty seconds, but they fall off up to that point. In table XII there are no cases having no deviation at twenty, falling off from seven cases, and later rising to ten.

The influence of this factor on the mode of each time interval can be shown in a representative fashion in table XII where the modes gradually rise from a two centimeter deviation to between four and five, later to drop again to three centimeters. The maximums in curves such as this one show the same effect, for instance: the maximum of this table at one second lies at only three centimeters deviation, to rise to eight at twenty seconds, falling finally to six.

A similar inspection of tables XXV to XXVIII, females of

a similar age group, will be found to show the same effects, namely, zero readings falling until a twenty second exposure is reached when they begin to rise, modes and maximums following closely. Other age groups show the same tendencies, although maximums, averages and modes lie differently. This is attributable to the fact that fewer cases make the results less dramatic and, since age has an influence as will be shown later, this too, must make itself felt.

Examining the graphs which represent the average deviations of these groups, we find that in all cases the phenomenon begins to a measurable extent in one second, increases to a maximum from ten to thirty-five seconds and tends to disappear after that time.

The most valid expression of this time influence is an average time curve whereby all of the results of the 124 individuals tested for all of their four quadrants are combined as in the following table:

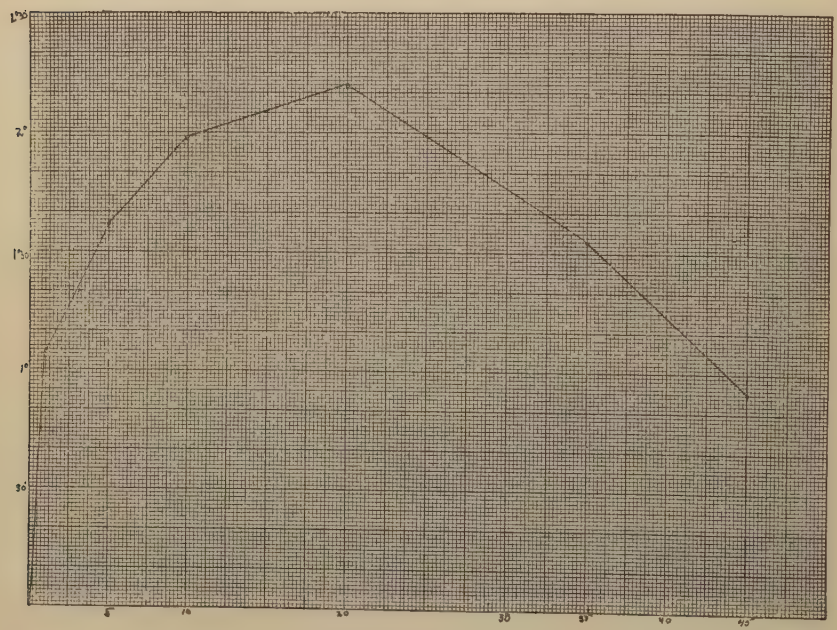


Table XXXIV

Seconds Exposure—	1	3	5	10	20	35	45
Average Deviation—	1° 5′	1° 20′	1° 37′	1° 59′	2° 12′	1° 33′	55′

Here it can be readily seen that the phenomenon is measurable even at one second exposure and that it rises by discreet but fairly comparable steps to a maximum of 20 seconds and again diminishes after that time interval until it shows signs of disappearing and in fact in a number of cases, 211 out of 496, it did actually do so. As far as the commencement of the curve is concerned, 292 cases out of 496 gave a positive reading of one centimeter deviation or over at one second. The above results will show that the phenomenon is directly affected by time, both individually and when compared in large groups; that its maximum is around 20 seconds; that it is measurable in all individual cases at ten seconds, and that it tends to disappear before one minute, although it does not always do so entirely.

Effect of Sex

In order to show the influence of sex on the phenomenon under investigation, the maxima of tables 1-16 (Males) and tables 17-32 (Females) have been combined so as to give the results presented in the following table:

TABLE XXXV

MALES			FEMALES	
Time		*Deviation*	*Time*	*Deviation*
	Age 4-7		*Age 4-7*	
R.U.	5	2° 20′	10	1° 30′
L.U.	10	1° 50′	10	2° 20′
R.D.	20	1° 30′	20	2° 20′
L.D.	20	3° 30′	20	3°
	Age 10-14		*Age 10-14*	
R.U.	20	2° 30′	20	2° 20′
L.U.	20	2°	35	3° 40′
R.D.	10	2° 20′	20	1° 50′
L.D.	20	3° 30′	20	4° 00′
	Age 18-23		*Age 18-23*	
R.U.	20	1° 50′	20	1° 20′
L.U.	20	2° 20′	10	2° 30′
R.D.	20	2° 10′	35	2° 10′
L.D.	20	3° 30′	20	3° 20′
	Age 45 and Over		*Age 45 and Over*	
R.U.	10	1° 10′	10	1° 00′
L.U.	20	2° 10′	10	1° 50′
R.D.	10	1° 30′	20	1° 10′
L.D.	20	2° 20′	20	2° 40′

It can be seen that there is a slight tendency for the females to reach their maximum earlier and also for the maximums on the left quadrands to be slightly greater in the cases of the females.

Comparing the average of all the male results with that of the females we obtain the following tables:

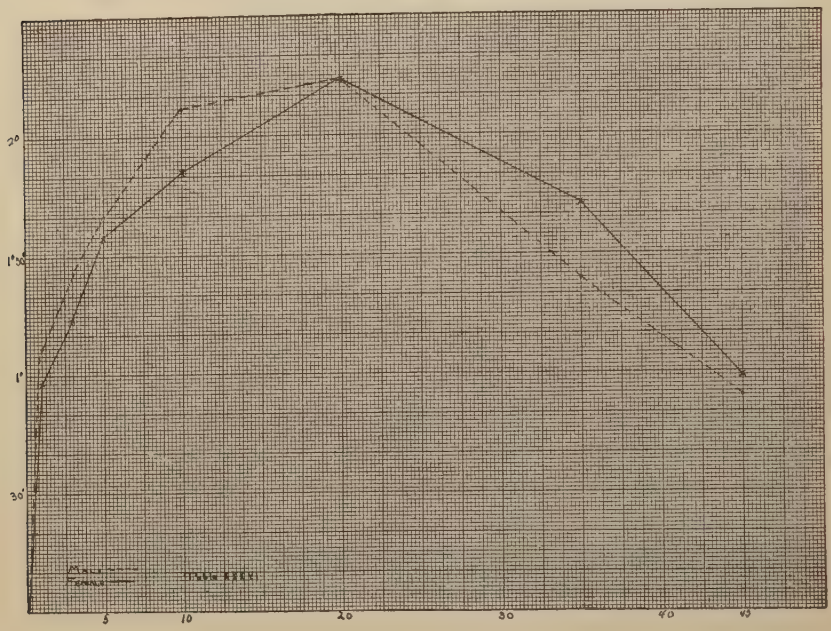


TABLE XXXVI

Sex	*Time:*	*1*	*3*	*5*	*10*	*20*	*35*	*45*
Male:		1° 7′	1° 26′	1° 40′	2° 7′	2° 14′	1° 24′	0° 54′
Female:		58′	1° 14′	1° 35′	1° 51′	2° 14′	1° 43′	0° 59′

By examining this table and the accompanying chart we can see that the females require a slightly longer exposure to obtain the same deviation as the males or in other words the deviation for the same exposure is not as great as that of the males. However, the point of time of the maximum and the amount of maximum deviation of both sexes agree exactly and it can be seen that the period of falling off does not differ sufficiently between the two sexes to make this part of the comparison of any importance. In considering the value of these

findings it may be said that obviously we cannot compare the result in a single female with a single male in regard to time curves but comparison of the time curves in a normal male and normal female should agree to a great extent with the mass curve of either.

The Variations in the Four Quadrants

In studying a phenomenon which is as basic organically as this one, it might be felt that measurements in all quadrants should be very much the same. The differences, however, are much greater than might be expected. There are three ways that these differences might be expressed. First, by comparing the time curves of the two sides in a single individual; secondly, by comparison of the various curves in each sub-group and, thirdly, by comparing the gross averages of all of the groups as expressed in degrees in order to eliminate the factor of arm length. In the individual cases inspection shows that in the lower quadrant there is a marked difference between the curve of the right and left side, that in 203 cases out of 248 cases practically all of the readings were greater on the left side than on the right. The same general relationship between right and left in individual cases holds true and by inspecting table XXXV we find that in a majority of cases the left was greater than the right and had its maximum at a later time interval.

It could be seen that in individual cases the greater deviation occurred on the left, as shown in the following table:

TABLE XXXVII

MALES (18-23)

Cases in which rt. predominated by:	1 second		3 seconds			
	1 cm.	*2 cm.*	*1 cm.*	*2 cm.*	*3 cm.*	*4 cm.*
	7	2	2	2	0	0
Cases in which left predominated by:						
	9	3	6	3	1	1

	10 seconds			20 seconds		
	1 cm.	*2 cm.*	*5 cm.*	*6 cm.*	*1 cm.*	*2 cm.*	*6 cm.*
Rt.—	6	0	1	0	3	8	0
Left—	6	4	0	1	5	7	1

	35 seconds						45 seconds
	1 cm.	*2 cm.*	*3 cm.*	*4 cm.*	*5 cm.*	*6 cm.*	*1 cm.*
Rt.—	1	3	1	1	0	0	6
Left—	1	2	4	1	1	1	3

The maximum differences between the two lower quadrants are:

Seconds:	*1*	*3*	*5*	*10*	*20*	*35*	*45*
Male:	4	4	5	6	7	6	5 cm.
Female:	3	5	5	5	6	4	5 cm.

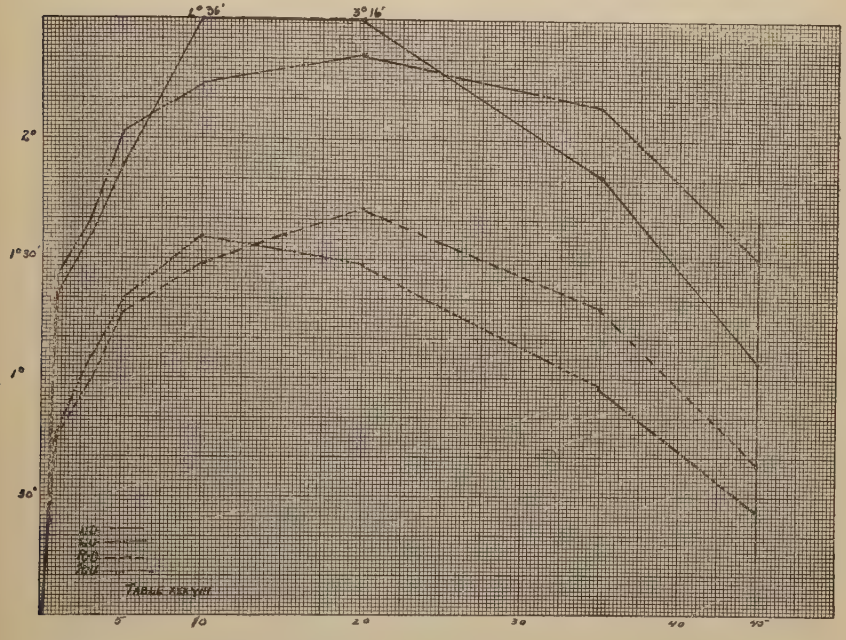
The general relationships in the quadrants in each group can be seen by inspecting the charts accompanying that group, and it can be seen that the average deviation in the left down is always greater in all times and that both left quadrants are greater than both right, even though sometimes the right down quadrant exceeds the left up. Averaging all of the results for all groups to show a comparison between quadrants we obtained the following results:

TABLE XXXVIII

	1	*3*	*5*	*10*	*20*	*35*	*45*
R.U.	46′	1° 5′	1° 19′	1° 36′	1° 29′	58′	28′
L.U.	1° 26′	1° 40′	2° 1′	2° 13′	2° 21′	2° 8′	1° 30′
R.D.	45′	59′	1° 16′	1° 29′	1° 43′	1° 18′	38′
L.D.	1° 21′	1° 36′	1° 53′	2° 36′	3° 16′	1° 51′	1° 4′

It can be seen definitely that the figures throughout the right quadrants, both up and down, are less than those of the equivalent left quadrants; both the maximums and the other averages are low in the right hand side and can be seen to be less than the average of all of the readings (shown in the section on the effect of time), and fall off quite markedly to a rating of about one-half degree which is, compared to other averages, exceedingly small. The comparison of the up and down quadrants shows the lower quadrants to be decidedly greater in all readings than the upper quadrants. The general difference between the upper and lower quadrants in the sub-group curves may be said to be largely in the point where the maximum was obtained, usually at 10 seconds in the upper quadrants while in the lower quadrants it is at 20 seconds. (Table XXXV) However, this is not always the case and the reason for this may be interpreted as having some relationship to fatigue, the arm fatiguing in the upper quadrants more quickly than in the lower, because of the additional strain of holding it against gravity. The interpretation of the left being greater than the right is based on the fact that the right

hand, being used more than the left, has acquired a greater ability to coordinate than the left. Learning possibly has something to do with this, although in all probability the right motor reflexes become more coordinated because of the increased use of that hand and because of the adaptation of the central nervous system to these purely motor acts.



Since all of the cases which were investigated in the groups containing twenty-four individuals were right-handed and their results agreed with the curves of Table XXXVIII above, it is interesting to see if left-handedness would reverse the effect. It was possible to obtain five nurses who were left-handed and who fell in the same age group as the female cases from eighteen to twenty-three. By carrying out the procedure with these five individuals the following table of averages was obtained:

TABLE XXXIX

	1	*3*	*5*	*10*	*20*	*35*	*45*
L.D.	1.8	2.2	2.8	3.2	3.0	3.2	2.2
R.D.	2.0	2.4	2.2	3.4	3.8	3.2	1.6
R.U.	1.4	1.6	2.0	3.0	2.0	2.6	2.2
L.U.	1.4	2.0	1.6	2.4	2.4	2.2	1.0

When these results are translated into graphic form (Chart VIIA) we have quite decidedly the opposite of the previous eight charts. In other words, the highest curve is that of Right Down instead of Left Down. The next one is that of Left Down instead of Right Down as in the previous chart and the right up curve is superior to the left up curve, both in maximums and in the general course for all of the time periods. It is obvious, then, that the factors involved in making the left hand greater than the right hand in its average deviation in right handed people and in the same way the relationships in this last series (the left-handed series) making the right hand greater than the left hand, rests on the same basis in the central nervous system as does right-handedness and left-handedness. It is impossible to say, at the present time, whether this is a purely cortical function; whether it depends on training, that is, a learned function; or whether it has a physiological basis in the nervous system aside from mere cerebral localization.

Influence of Age

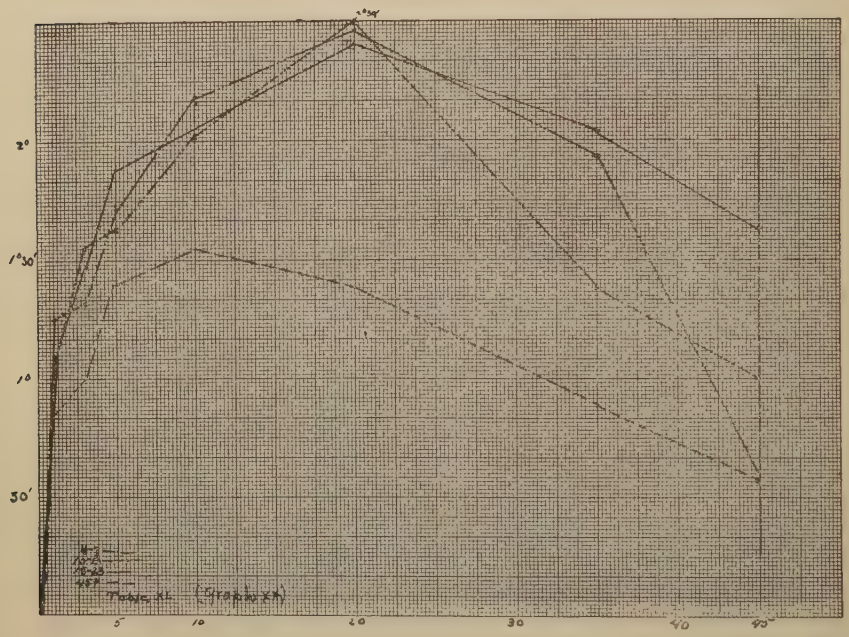
When the centimeter readings are converted into expressions of the angle at which the arm differs from the horizontal after the exposure, and curves expressing the time influence in each quadrant are compared for all ages, we obtain results which illustrate the influence of age as regards the different quadrants. It has been shown previously that the left down quadrant in both males and females shows the greater deviation, so that another examination of this quadrant will give the best idea of the results. It is easy to see in this particular quadrant that the lowest curve on the chart is that of the males forty-five years old and the maximum deviation in this curve is reached at twenty seconds, rising only to 2° 20′. The curve of the males, eighteen to twenty-three, reaches a maximum at the same time interval and this can be seen to be higher, namely, 3° 30′ and the curve of the older children is at 3° 40′. The same time interval can be seen to be the maximum in the case of the young children and this maximum is 10 minutes higher than any of the other curves. Although each curve in this quadrant does not run parallel to the one below it, the general tendency of each can easily be seen to follow quite closely its maximum. In the equivalent case, in the females in the left down quadrant it can be seen that the situa-

tion is somewhat different. The general tendency is, of course, for the various ages to bear practically the same relationship as in the previously discussed curve; but the curve of the young children lies below that of the older children and young adults. This can be explained by pointing out that the difference between the right and left in the young children, in this phenomenon, is not marked and that while in all the other groups but this one, the left shows a greater deviation than the right, in the case of young female children the leveling between the two quadrants will have a neutralizing effect on the highest curves.

In the right down quadrant the effect in both the case of the males and females is similar; the young children do not seem to follow any regular rule but the maximums of the other three curves run parallel and in the 45 year group the maximums are lowest; the young adults next, and the older children at the top. In the case of the right down in the females, the maximum is slightly anomalous in the older children, but the general shape of the curves suggest that all of the deviations decrease with age, the irregular rate of onset and the fact that the curves do not fall off in a parallel manner as a normal curve would do making the maximum readings more significant than the shape of the curves. However, in the case of the left down in both males and females, the areas limited by the curves suggest that other times than the maximum may also be considered significant. The upper quadrants are more or less the same as the lower ones following the same general outline, and, although the curves of the young children may commence as rapidly as those of the older children and reach their maximums at approximately the same time, both their maximum and the general trend of these curves are less than those of the older children and the young adults. The curves of the three older ages in the upper quadrants can be seen to follow the same general trend as in the lower.

To summarize the interpretation of the results of investigation in the various quadrants, it is easy to see that age has an influence particularly in the maximum and the shapes of the curves, and the curves of the older children run parallel to those of the adults having their maximums, as a general rule, at about the same point in time, although occasionally these maximums occur slightly earlier. In the case of the older adults, while these curves and maximums, too, run parallel to

the younger adults, the areas of their curves and their maximums are below those of the groups from 18 to 23. The irregularity found in the curves representing the very small children may be interpreted in the light of the fact that, while the deviations were smaller in the point of the actual angles, they were still very great from the standpoint of the ability of the child to adjust himself, which interpretation falls in line with the findings of investigators concerning the reflexes of Magnus and DeKleijn, in that the nervous system, as regards the postural and righting reflexes, tends to have the maximum output of these reflexes when they are demanded, that is, in the earlier years and then later these gradually diminish.



It is necessary, as has just been done, to study the effect of the various groups individually in order to interpret the gross table below. This table is composed of the average of all of the curves for each age in all quadrants so that right and left, both up and down for both male and female in each group will be compared to the other three age groups. (Table XL.)

The general trend throughout the curves, as shown in graph 20 is not very consistent except in the case of the older group. Here it is clear that the amount of deviation of all time inter-

TABLE XL

Age:	*1*	*3*	*5*	*10*	*20*	*35*	*45*
4-7	1° 15′	1° 19′	1° 43′	2° 11′	2° 27′	1° 56′	0° 36′
10-13	1° 5′	1° 33′	1° 38′	2° 1′	3° 39′	1° 23′	1° 0′
18-23	1° 6′	1° 28′	1° 44′	2° 10′	2° 23′	2° 2′	1° 38′
45-/—	0° 51′	1° —	1° 24′	1° 33′	1° 23′	0° 53′	0° 34′

vals is much less than for any of the other groups. We may regard the maximum points on these curves as being of most significance, perhaps, and the order beginning with the highest is as follows: older children, younger children, younger adults, and older adults. The maximum for the latter group occurs early, which may have been due to a fatigue effect, and rises only approximately three-fifths as high as the average maximum point of the other three curves. The maximum for the older group is 1° 33′ while that for the next lowest group (younger adults) is 2° 23′. In general, the data seem to support the conclusion that the phenomenon shows a fairly consistent tendency to decrease with increasing age.

CONCLUSION

In conclusion, one must notice how remarkable it is that the persistance of posture begins to act so quickly. Since in every day life it is not rare at all for a person to remain in one position more than one second, the conclusion can be drawn that all of his acts are influenced by the persistance of posture, and the effect of it would be that we change our position less suddenly than we intend, and that the transition from one position to another is not as abrupt as one might think. The longer one stays in a position the less abrupt the transition to the next position must be, but, of course, if a sufficiently long time has elapsed since the time one assumes the position and the time that the next position is adapted, the influence is minimized. It is a rare occasion, however, when one stays longer than twenty or thirty seconds in a single position, at least one's arms are not held in the same position that long and so the fact that too long an exposure decreases the efficiency of that exposure, gives these findings a biological significance. This too, would serve to explain why women reach their maximums earlier than men and the next question to be examined, based on our results, would be the problem of how long human beings keep one limb in one position when they are not asleep. If one could have a comparison of the differences obtained between men and women in such an investigation, one could give a more definite answer to this special problem.

With our present state of knowledge it is difficult to interpret why the downward quadrants show greater deviation than the upward quadrants, but it might be connected with the special structure of the shoulder joint and comparative examinations of other joints would be necessary to settle the question.

The greater deviation of the left hand, in right-handed people and the right hand in left-handed people, could be reconciled with the general idea that the phenomenon is connected especially with postural tendencies which are unknown, at the time, to be individual and one is led to believe that these postural tendencies will be more strong the less one arm is used for voluntary purposes. The truth of this interpretation is doubtful, because one knows that the more skillful right arm reacts more strongly to the postural tendencies in connec-

tion with the turning of the head, which are akin to this phenomenon.

Another fact of special importance seems to stand out and that is that the females reach their maximum in a shorter time than do the males, and this is probably related to the established belief that the muscular actions of females are less steady and persistent than those, particularly postural activities, of the male. On the other hand, the fact that the males show a greater reaction on the right side and the females on the left is not so significant and at the present time cannot be interpreted.

In regard to the findings that the males have a greater tendency to react on the right side than the females, no definite interpretation is possible at the present time, although it may have some connection with the fact that the right arm in men is more strong than in women and fatigue effects are eliminated to a greater extent.

It was to be expected that, with the increase of age, the phenomenon would tend to diminish, though we know that all inherent nervous activities more or less diminish with the progress of age until finally in the senile individual we find the rigid in mien, and the lack of expression with a rigid, almost Parkinsonian attitude. It is well known that these changes are related to the functional or anatomical degenerations in the strio-pallida-substantia nigra system, and, although postural reflexes of other types have not been studied sufficiently with similar methods, we would expect in these also decreases proportional to the age.

The phenomenon studied here and the phenomena of posture and righting reflexes are well known to be akin to one another, and since the phenomenon is of interest not only to the psychologist but also to the clinician some particular facts in the findings deserve stress in the matter of application.

1. There was not found a single case in which the phenomenon was completely absent in any one quadrant and the finding in an individual of one quadrant without a single deviation, should raise the question of a pathological cause.

2. So far no adequate method has been found to prove that the persistance of posture is ever increased, but the above results are sufficient to suggest the possibility of such a method. The tables show that no normal person reached a difference of more than four centimeters at the first second, so that

values above that at the same time interval would show an increase in the phenomenon. Cases of exopthalmic goitre and cerebellar lesions should be studied by the method of exposures of one second.

3. The results of the above experiments suggest a means for determining whether or not there is pathology in those cases in which there is found to be a difference between the two sides. In normal people there is never a difference greater than seven centimeters between the two sides and even this is rather rare. This occurred only in two cases out of the whole 114 studied, and since it occurred at twenty seconds, clinically every pathological case should be studied for one second exposure and for twenty second exposure. However, if there should be no results, then an exposure of thirty-five seconds should be made, as maximums in some cases occurred at this time. The phenomenon is certainly a complex one, but it is so constant in the normal that it can be used as a test in abnormal cases.

SUMMARY

The results of this study may be summarized as follows:

1. The phenomenon of postural persistance appears even when the exposure is no longer than that required for the mere movement of the arm downward, or upward, followed by an attempt to return it immediately to the horizontal.

2. The phenomenon shows a definite increase with increase in exposure time until a maximum is reached between ten and thirty-five seconds, the maximum usually occurring at about 20 seconds.

3. The amount of deviation differs from quadrant to quadrant somewhat, being the highest in most cases in the left down quadrant. This relationship is reversed for left handed people.

4. The sex difference in general was too slight to be significant.

5. There appears to be a fairly consistent tendency for the phenomenon to decrease with age, the decrease being especially large in the case of older adults.

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APPENDIX

TABLE I

MALES 4—7

1	*3*	*5*	*10*	*20*	*35*	*45*	*Deviation*
			Right Up				
1	2	1	3	4	2	3	0 cm
3	3	3	3	2	3	4	1 cm
2	0	1	0	0	0	0	2 cm
1	2	0	0	1	1	0	3 cm
0	0	1	1	0	1	0	4 cm
0	0	1	0	0	0	0	5 cm
AV. 1.4	1.3	2.	1.	.7	1.4	.5	
1° 40′	1° 30′	2° 20′	1° 10′	0° 50′	1° 40′	0 °40′	

TABLE II

1	*3*	*5*	*10*	*20*	*35*	*45*	*Deviation*
			Left Up				
4	3	4	2	3	4	5	0 cm
2	1	0	2	3	2	2	1 cm
1	2	1	1	1	1	0	2 cm
0	1	2	1	0	0	0	3 cm
0	0	0	1	0	0	0	4 cm
AV. .6	1.1	1.1	1.6	.7	.6	.3	
0° 40′	0° 20′	0° 20′	1° 50′	0° 50′	0° 40′	0° 20′	

TABLE III

MALES 4—7

1	*3*	*5*	*10*	*20*	*35*	*45*	*Deviation*
			Right Down				
2	3	2	2	3	1	4	0 cm
2	3	1	2	1	2	3	1 cm
2	0	2	2	1	3	0	2 cm
0	1	1	1	2	1	0	3 cm
0	0	1	0	0	0	0	4 cm
AV .1	.8	1.7	1.1	1.3	1.5	.4	
0° 10′	1° 00′	1° 50′	1° 20′	1° 30′	1° 40′	30′	

TABLE IV

1	3	5	10	20	35	45	Deviation
			Left Down				
1	2	2	1	0	2	3	0 cm
1	3	1	1	0	1	2	1 cm
1	0	0	2	2	2	2	2 cm
2	0	2	1	2	1	0	3 cm
2	1	2	2	2	1	0	4 cm
0	1	0	0	1	0	0	5 cm
0	0	0	1	0	0	0	6 cm
AV 2.4	1.7	2.2	3.1	3.3	1.7	.9	
2°50′	2°10′	2°30′	3°40′	3°50′	2°10′	1°00′	

TABLE V

MALES 10—14

1	3	5	10	20	35	45	Deviation
			Right Up				
5	3	6	5	5	15	13	0 cm
7	6	1	2	1	1	1	1 cm
1	2	4	2	2	1	0	2 cm
2	3	2	2	1	0	0	3 cm
0	1	1	1	2	0	1	4 cm
0	0	1	2	3	1	0	5 cm
0	0	0	1	1	0	0	6 cm
AV 1.	1.5	1.6	2.1	2.5	.5	.5	.3
1° 00′	1° 30′	1° 30′	2° 10′	2° 30′	0° 30′	0° 20′	

TABLE VI

1	3	5	10	20	35	45	Deviation
			Left Up				
5	5	6	5	7	9	8	0 cm
3	3	2	2	0	1	3	1 cm
4	2	6	2	0	1	2	2 cm
2	3	0	2	4	1	1	3 cm
1	1	1	3	1	1	1	4 cm
0	1	0	1	3	1	0	5 cm
0	0	0	0	0	1	0	6 cm
AV 1.4	1.7	1.2	1.9	2.	1.4	.9	
1° 20′	1° 40	1° 10′	1° 50′	2° 00′	1° 25′	0° 50′	

TABLE VII

MALES 10—14

1	*3*	*5*	*10*	*20*	*35*	*45*	*Deviation*
			Right Down				
8	8	7	6	5	10	9	0 cm
3	1	2	2	3	2	1	1 cm
2	2	4	3	1	1	2	2 cm
1	1	0	4	3	1	2	3 cm
1	2	2	1	2	0	1	4 cm
0	1	0	1	1	1	0	5 cm
0	0	0	1	0	9	0	6 cm
AV. .9	1.4	1.2	2.3	1.7	.8	1.	
50′	1° 20′	1° 10′	2° 20′	1° 40′	0° 50′	1° 00′	

TABLE VIII

1	*3*	*5*	*10*	*20*	*35*	*45*	*Deviation*
			Left Down				
5	6	6	4	0	7	8	0 cm
4	2	1	2	2	2	2	1 cm
2	3	3	1	2	3	2	2 cm
2	1	4	2	3	2	1	3 cm
2	3	0	5	4	1	1	4 cm
0	0	1	0	4	0	1	5 cm
0	0	0	1	0	0	0	6 cm
AV. 1.5	1.5	1.6	2.4	3.4	1.2	1.2	
1° 30′	1° 30′	1° 30′	2° 20′	3° 30′	1° 10′	1° 10′	

TABLE IX

MALES 18—23

1	*3*	*5*	*10*	*20*	*35*	*45*	*Deviation*
			Right Up				
6	5	8	6	8	14	17	0 cm
5	4	3	5	1	0	0	1 cm
7	5	6	3	4	4	2	2 cm
4	7	4	3	4	2	3	3 cm
1	2	2	5	3	3	1	4 cm
1	1	1	2	2	1	1	5 cm
0	0	0	0	2	0	0	6 cm
AV. 1.3	2.	1.3	2.1	2.3	1.5	.9	
1° 10′	1° 40′	1° 10′	1° 40′	1° 50′	1° 20′	0° 40′	

TABLE X

1	3	5	10	20	35	45	Deviation
			Left Up				
6	6	4	7	6	6	7	0 cm
8	8	11	5	2	2	5	1 cm
7	6	2	3	3	5	3	2 cm
2	0	4	2	6	4	3	3 cm
1	1	1	3	0	3	2	4 cm
0	3	1	2	6	2	1	5 cm
0	0	1	2	0	1	2	6 cm
0	0	0	0	1	1	1	7 cm
AV. 1.3	1.6	1.8	2.1	2.6	2.4	2.2	
1° 10′	1° 20′	1° 30′	1° 40′	2° 10′	2° 00′	1° 40′	

TABLE XI

MALES 18—23

1	3	5	10	20	35	45	Deviation
			Right Down				
8	8	7	2	6	12	16	0 cm
7	3	3	7	2	0	2	1 cm
6	7	5	1	3	3	2	2 cm
1	4	7	6	2	3	2	3 cm
1	2	2	4	4	3	0	4 cm
1	0	0	3	5	0	2	5 cm
0	0	0	1	2	3	0	6 cm
0	0	0	0	0	0	0	7 cm
0	0	0	0	0	0	0	8 cm
AV. 1.3	1.5	1.8	2.7	2.8	2.3	.9	
1° 10′	1° 10′	1° 30′	2° 10′	2° 10′	1° 50′	0° 40′	

TABLE XII

1	3	5	10	20	35	45	Deviation
			Left Down				
7	6	2	2	0	8	10	0 cm
7	2	2	1	0	2	3	1 cm
8	3	5	4	4	3	3	2 cm
2	8	3	3	3	3	5	3 cm
0	2	6	4	4	4	1	4 cm
0	1	4	3	4	2	1	5 cm
0	2	2	4	4	2	1	6 cm
0	0	0	2	2	0	0	7 cm
0	0	0	1	3	0	0	8 cm
AV. 1.2	2.4	3.2	3.9	4.4	2.6	1.7	
1° 00′	2° 00′	2° 40′	3° 10′	3° 30′	2° 10′	1° 20′	

TABLE XIII

MALES 45 AND OVER

1	3	5	10	20	35	45	Deviation
			Right Up				
9	7	8	8	9	12	13	0 cm
2	3	2	1	4	2	2	1 cm
2	3	3	0	1	0	0	2 cm
1	2	0	3	0	1	0	3 cm
1	0	1	3	1	0	0	4 cm
0	0	1	0	0	0	0	5 cm
AV. .9	1	1.1	1.5	.7	.3	.1	
0° 40′	0° 50′	1° 00′	1° 10′	0° 40′	0° 20′	0° 10′	

TABLE XIV

1	3	5	10	20	35	45	Deviation
			Left Up				
5	5	4	5	4	5	7	0 cm
3	4	2	1	1	4	2	1 cm
4	2	1	1	3	1	2	2 cm
3	3	2	3	2	1	1	3 cm
0	1	4	3	2	1	1	4 cm
0	0	1	2	1	2	1	5 cm
0	0	1	0	1	1	1	6 cm
0	0	0	0	1	0	0	7 cm
AV. 1.3	1.4	2.5	2.3	2.6	1.9	1.6	
1° 10′	1° 10′	2° 10′	1° 50′	2° 10′	1° 40′	1° 20′	

TABLE XV

MALES 45 AND OVER

1	3	5	10	20	35	45	Deviation
			Right Down				
6	5	7	4	7	10	12	0 cm
5	3	3	3	4	3	1	1 cm
2	4	0	2	2	1	0	2 cm
1	2	3	4	2	1	1	3 cm
1	1	2	1	0	0	1	4 cm
0	0	1	1	0	0	0	5 cm
AV. 1.1	1.4	1.6	1.9	.9	.5	.5	
1° 00′	1° 10′	1° 20′	1° 30′	0° 40′	0° 30′	0° 30′	

TABLE XVI

1	3	5	10	20	35	45	Deviation
			Left Down				
5	5	4	3	1	8	10	0 cm
4	3	5	2	3	3	2	1 cm
3	2	2	3	2	1	1	2 cm
2	3	2	1	2	1	2	3 cm
1	1	1	3	5	1	0	4 cm
0	1	0	2	1	1	0	5 cm
0	0	1	0	1	0	0	6 cm
0	0	0	1	0	0	0	7 cm
AV. 1.3	1.7	1.7	2.7	2.9	1.1	.7	
1° 10′	1° 20′	1° 20′	2° 10′	2° 20′	1° 00′	0° 40′	

TABLE XVII

FEMALES 4—7

1	3	5	10	20	35	45	Deviation
			Right Up				
5	6	4	4	3	5	7	0 cm
0	2	2	2	3	2	2	1 cm
2	1	1	0	3	2	0	2 cm
2	0	2	2	0	0	0	3 cm
0	0	0	1	0	0	0	4 cm
AV. 1.1	.4	1.1	1.3	1.	.7	.2	
1° 20′	0° 30′	1° 20′	1° 30′	1° 20′	0° 50′	0° 10′	

TABLE XVIII

1	3	5	10	20	35	45	Deviation
			Left Up				
4	3	3	3	1	2	5	0 cm
2	2	3	0	3	2	2	1 cm
3	2	3	2	2	3	2	2 cm
0	0	0	2	1	0	0	3 cm
0	2	0	2	2	1	0	4 cm
0	0	0	0	0	1	0	5 cm
AV. 1.	1.6	1.	2.	2.	1.9	0.7	
1° 10′	1° 50′	1° 10′	2° 20′	2° 20′	2° 20′	0° 50′	

TABLE XIX

FEMALES 4—7

1	3	5	10	20	35	45	Deviation
			Right Down				
6	5	4	5	3	4	7	0 cm
2	3	2	1	1	1	1	1 cm
1	1	1	1	2	2	1	2 cm
0	0	2	1	1	1	0	3 cm
0	0	0	1	2	1	0	4 cm
AV. .4	.6	1.1	1.1	2.	1.9	.3	
30′	40′	1° 20′	1° 20′	2° 20′	2° 20′	0° 20′	

TABLE XX

1	3	5	10	20	35	45	Deviation
			Left Down				
5	5	4	2	1	3	6	0 cm
2	1	2	0	2	0	3	1 cm
1	2	2	3	0	3	0	2 cm
1	1	1	3	3	3	0	3 cm
0	0	0	1	3	0	0	4 cm
AV. .8	1.	1.	2.1	2.6	1.8	.3	
1	1° 10′	1° 10′	2° 30′	3°	2° 20′	20′	

TABLE XXI

FEMALES 10—14

1	3	5	10	20	35	45	Deviation
			Right Up				
8	7	5	5	4	6	10	0 cm
3	1	3	2	4	3	2	1 cm
2	3	3	0	2	2	1	2 cm
2	2	3	3	0	3	1	3 cm
0	1	1	4	1	0	1	4 cm
0	1	0	0	2	1	0	5 cm
0	0	0	1	2	0	0	6 cm
AV. .9	1.5	1.5	2.2	2.3	1.4	.7	
50′	1° 30′	1° 30′	2° 10′	2° 20′	1° 20′	40′	

TABLE XXII

1	3	5	10	20	35	45	Deviation
			Left Up				
6	2	2	5	1	2	1	0 cm
3	4	0	1	2	1	3	1 cm
1	2	0	3	2	2	3	2 cm
0	3	3	0	3	1	2	3 cm
3	2	4	4	2	1	2	4 cm
2	1	4	1	4	3	2	5 cm
0	1	1	0	1	4	1	6 cm
0	0	0	1	0	1	1	7 cm
0	0	1	0	0	0	0	8 cm
AV. 1.8	2.4	4.	2.3	3.3	3.7	3.1	
1° 50′	2° 20′	4° 00′	2° 20′	3° 20′	3° 40′	3° 00′	

TABLE XXIII

FEMALES 10—14

1	3	5	10	20	35	45	Deviation
			Right Down				
8	6	8	7	5	11	12	0 cm
3	4	4	5	3	2	1	1 cm
2	3	2	1	2	1	0	2 cm
1	2	1	2	1	1	1	3 cm
0	0	0	0	2	0	1	4 cm
1	0	0	0	1	0	0	5 cm
0	0	0	0	1	0	0	6 cm
AV. 1.0	1.1	.7	.9	1.9	.5	.3	
1° 00′	1° 10′	0° 40′	0° 50′	1° 50′	0° 30′	0° 20′	

TABLE XXIV

1	3	5	10	20	35	45	Deviation
			Left Down				
9	6	4	2	0	4	11	0 cm
3	2	5	4	1	3	0	1 cm
2	5	3	2	0	2	2	2 cm
1	1	0	5	5	2	1	3 cm
0	1	1	1	4	3	1	4 cm
0	0	2	1	3	0	0	5 cm
0	0	0	0	2	1	0	6 cm
AV. .7	1.3	1.7	2.1	4.	1.7	.7	
0° 40′	1° 20′	1° 40′	2° 10′	4° 00′	1° 40′	0° 40′	

TABLE XXV

FEMALES 18—23

1	3	5	10	20	35	45	Deviation
			Right Up				
11	8	8	7	10	10	17	0 cm
5	5	3	2	4	6	2	1 cm
2	4	8	4	3	2	0	2 cm
3	3	1	4	2	2	0	3 cm
2	4	2	2	1	1	1	4 cm
0	0	1	4	3	1	0	5 cm
1	0	1	1	1	1	3	6 cm
0	0	0	0	0	1	1	7 cm
AV. 1.3	1.6	1.7	2.3	1.7	1.6	1.3	
1° 10′	1° 20′	1° 20′	1° 50′	1° 20′	1° 20′	1° 10′	

TABLE XXVI

1	3	5	10	20	35	45	Deviation
			Left Up				
6	5	4	2	6	8	8	0 cm
9	1	4	1	4	1	0	1 cm
2	9	7	7	0	3	3	2 cm
4	3	5	5	6	0	2	3 cm
2	4	1	1	5	4	3	4 cm
1	2	2	7	0	2	4	5 cm
0	0	0	1	3	5	3	6 cm
0	0	1	0	0	0	1	7 cm
0	0	0	0	0	1	0	8 cm
AV. 1.6	2.3	2.4	3.1	2.5	3.0	2.9	
1° 20′	1° 50′	2° 00′	2° 30′	2° 10′	2° 30′	2° 30′	

TABLE XXVII

FEMALES 18—23

1	3	5	10	20	35	45	Deviation
			Right Down				
8	7	6	8	6	3	11	0 cm
5	4	3	2	2	3	1	1 cm
5	10	8	5	2	6	3	2 cm
3	0	2	4	4	5	4	3 cm
3	2	5	3	8	3	3	4 cm
0	1	0	2	2	3	2	5 cm
0	0	0	0	0	1	0	6 cm
AV. .7	.7	1.9	2.0	2.5	2.6	1.7	
40′	40′	1° 40′	1° 40′	2° 10′	2° 10′	1° 20′	

TABLE XXVIII

1	3	5	10	20	35	45	Deviation
			Left Down				
6	6	5	4	1	3	6	0 cm
2	0	2	1	1	3	3	1 cm
11	8	5	2	2	1	2	2 cm
4	4	9	4	5	4	0	3 cm
0	5	0	5	5	4	2	4 cm
1	1	1	6	5	2	6	5 cm
0	0	1	1	4	6	3	6 cm
0	0	1	1	0	1	1	7 cm
0	0	0	0	1	0	1	8 cm
AV. 1.7	2.2	2.4	3.3	4.	3.6	3.3	
1° 20′	1° 50′	2° 00′	2° 40′	3° 20′	3° 00′	2° 40′	

TABLE XXIX

FEMALES OVER 45 (to 58)

1	3	5	10	20	35	45	Deviation
			Right Up				
13	12	9	7	12	12	14	0 cm
1	1	2	2	1	2	1	1 cm
1	2	1	1	2	1	0	2 cm
0	0	1	3	0	0	0	3 cm
0	0	1	1	0	0	0	4 cm
0	0	1	1	0	0	0	5 cm
AV. .2	.3	1.0	1.1	.3	.3	.0	
10′	20′	0° 50′	1° 00′	20′	20′	0° 00′	

TABLE XXX

1	3	5	10	20	35	45	Deviation
			Left Up				
9	7	5	4	4	7	10	0 cm
3	2	2	1	2	2	2	1 cm
2	3	1	3	2	0	0	2 cm
1	2	4	3	4	3	0	3 cm
0	1	2	2	0	2	2	4 cm
0	0	1	2	2	0	1	5 cm
0	0	0	0	0	1	0	6 cm
0	0	0	0	1	0	0	7 cm
AV. .7	1.2	2.	2.3	2.3	1.6	1.	
40′	1° 00′	1° 40′	1° 50′	1° 50′	1° 20′	0° 50′	

TABLE XXXI

FEMALES OVER 45 (TO 58)

1	*3*	*5*	*10*	*20*	*35*	*45*	*Deviation*
			Right Down				
10	8	10	9	8	10	12	0 cm
2	3	2	2	3	3	2	1 cm
1	2	1	2	1	1	1	2 cm
1	1	2	2	0	1	0	3 cm
1	1	0	0	2	0	0	4 cm
0	0	0	0	0	0	0	5 cm
0	0	0	0	1	0	0	6 cm
AV. .7	.9	.7	.8	1.3	.5	.3	
0° 40′	0° 40′	0° 40′	0° 40′	1° 10′	0 30′	0° 20′	

TABLE XXXII

1	*3*	*5*	*10*	*20*	*35*	*45*	*Deviation*
			Left Down				
7	6	3	3	2	7	9	0 cm
1	1	1	2	1	2	2	1 cm
2	3	2	1	0	3	3	2 cm
2	2	5	3	4	1	1	3 cm
3	2	3	5	5	1	0	4 cm
0	0	2	1	3	1	0	5 cm
0	1	0	0	0	0	0	6 cm
AV. 1.5	1.8	2.6	2.5	3.2	1.7	.7	
1° 20′	1° 30′	2° 10′	2° 10′	2° 40′	1° 20′	0° 40′	

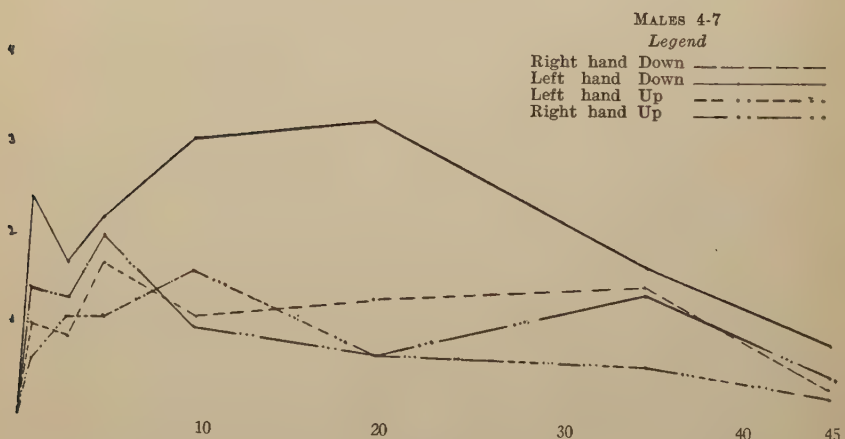

CHART I.

CHART II.

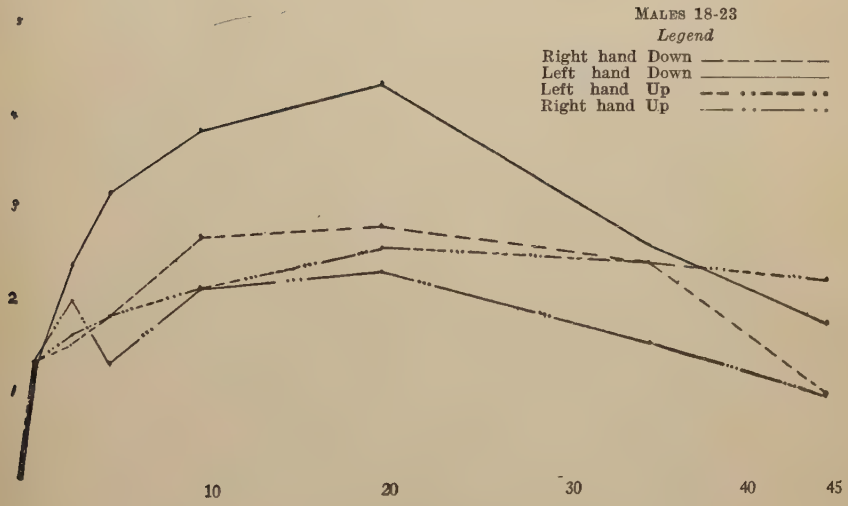

CHART III.

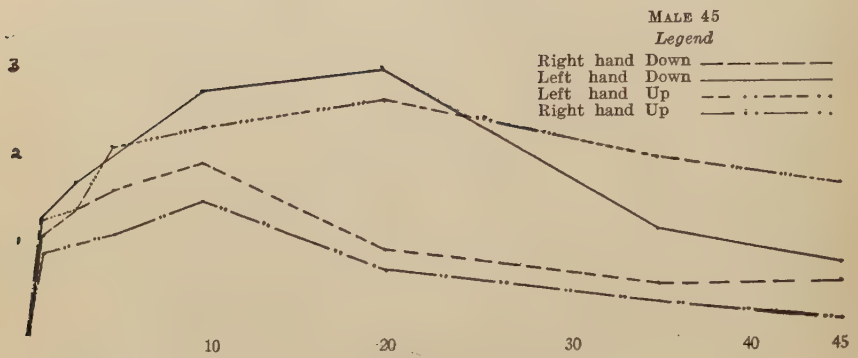

Chart IV.

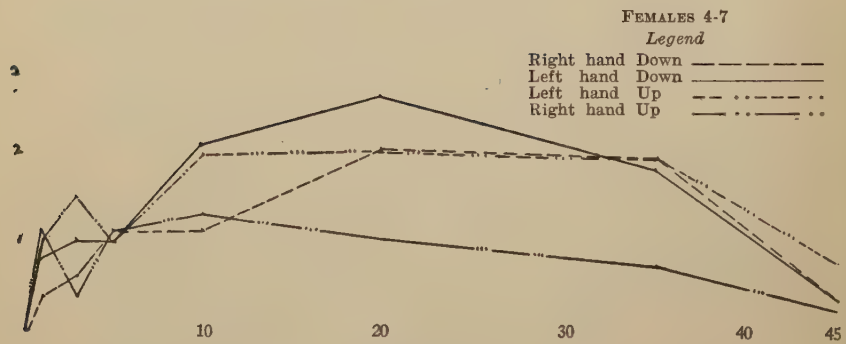

Chart V.

CHART VI.

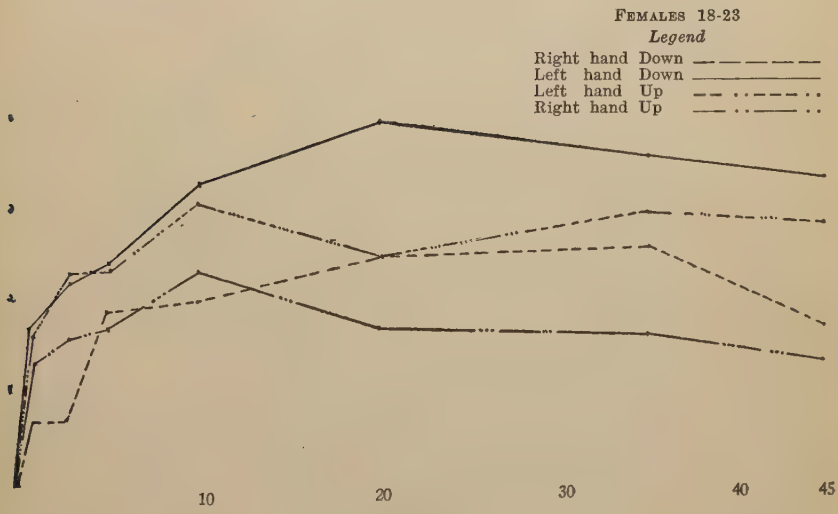

CHART VII.

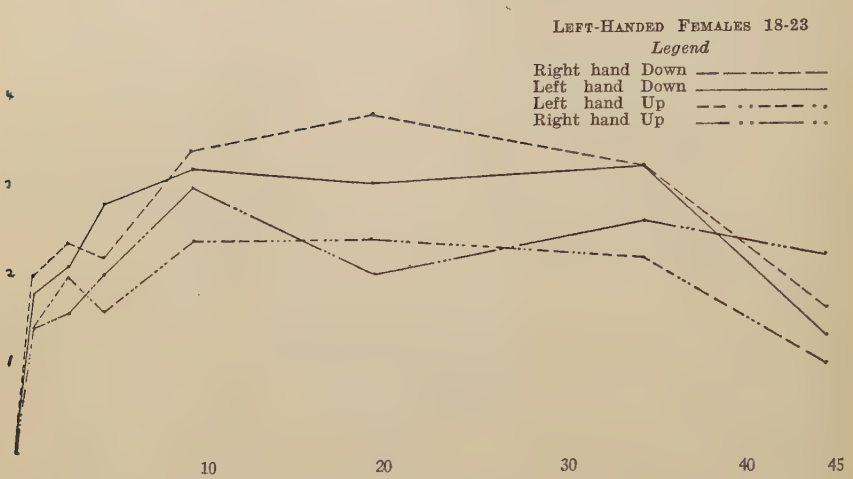

Chart VII. A

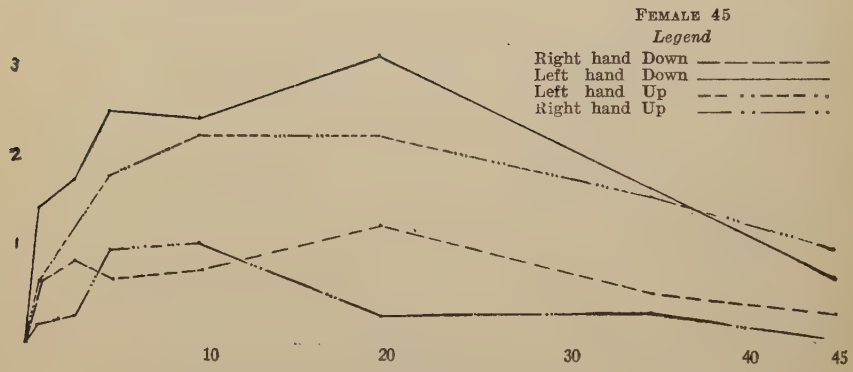

Chart VIII.

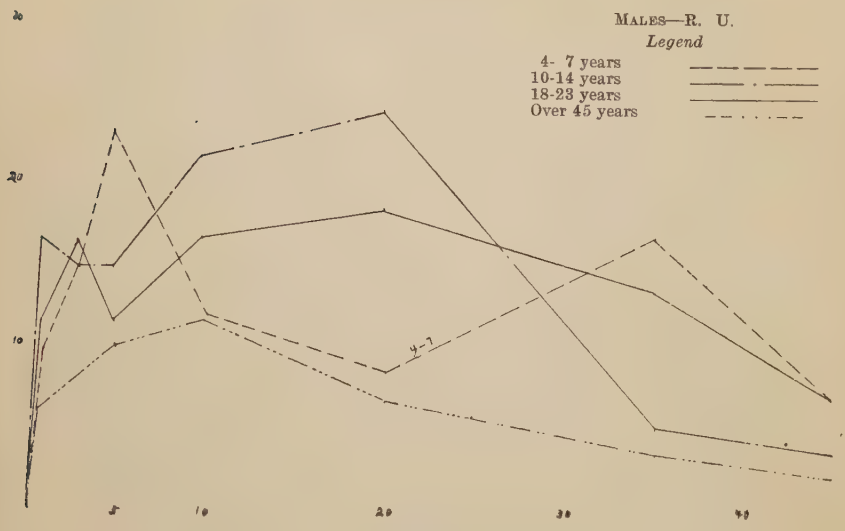

Chart IX.

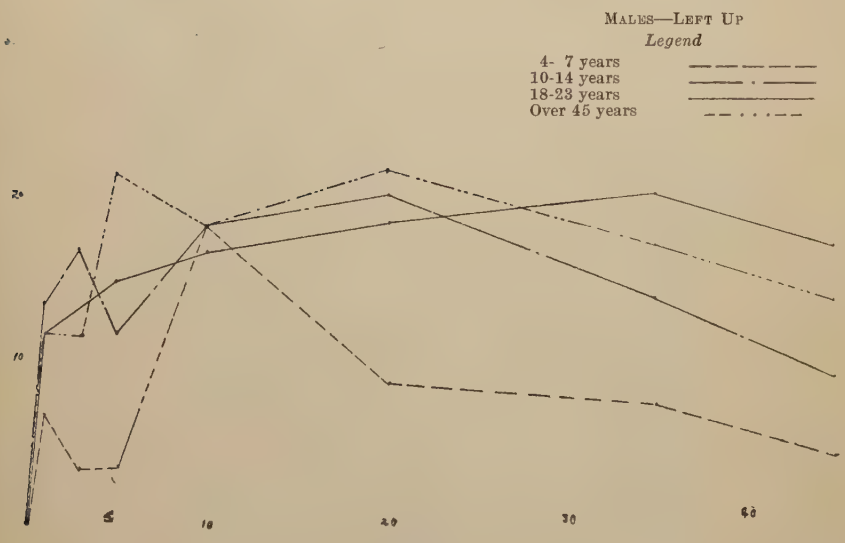

Chart X.

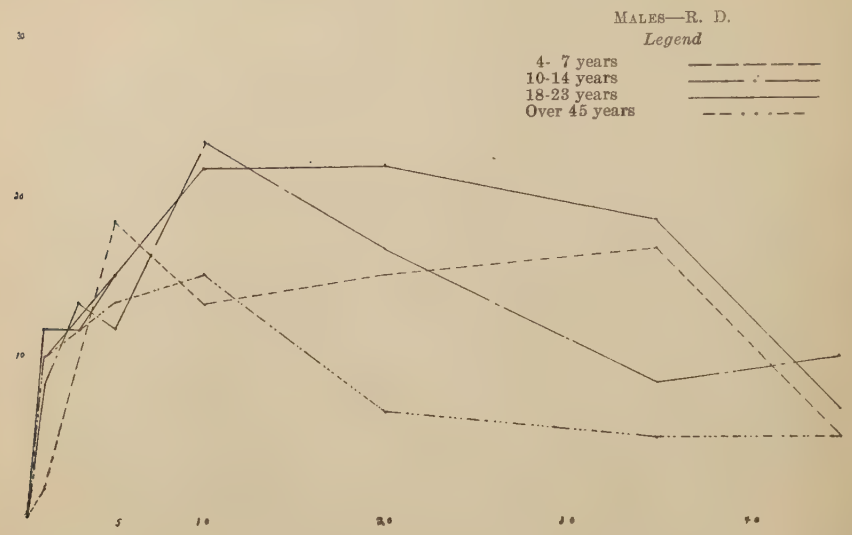

Chart XI.

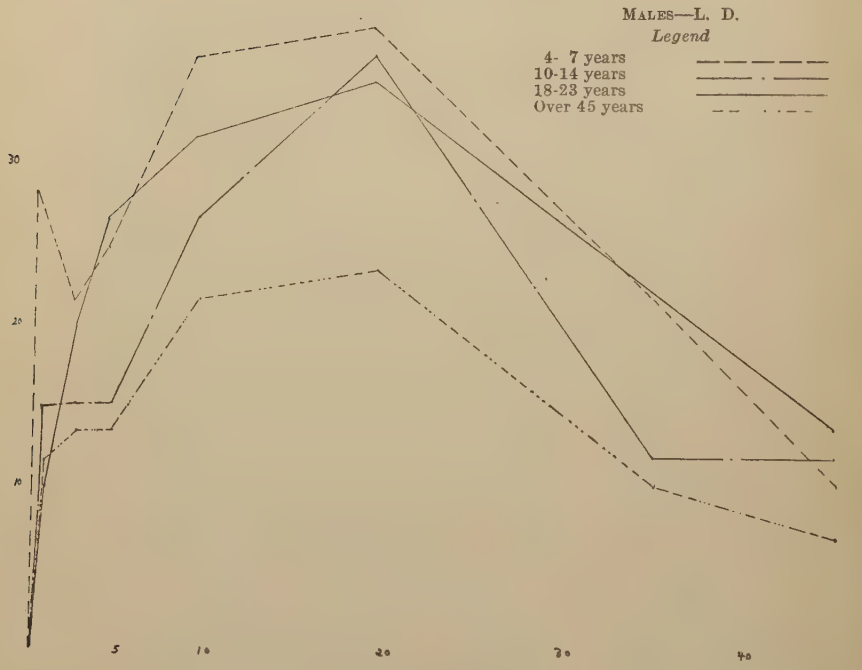

Chart XII.

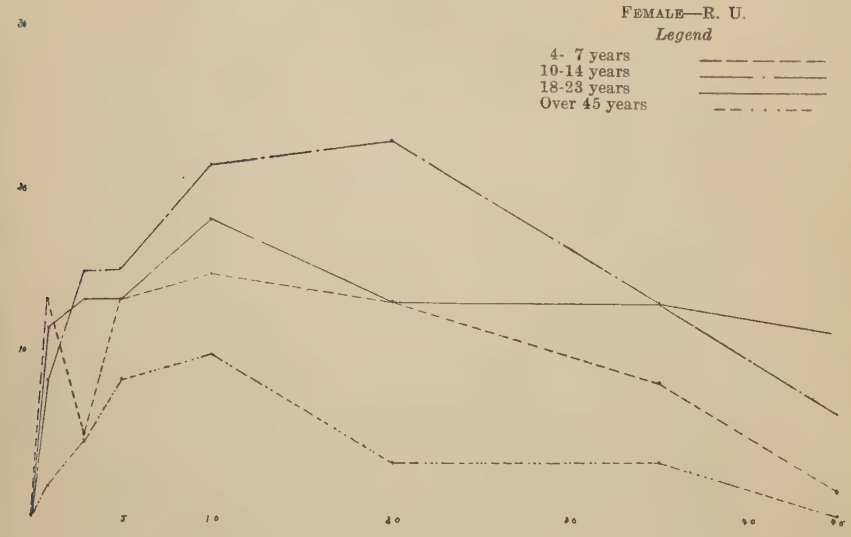

Chart XIII.

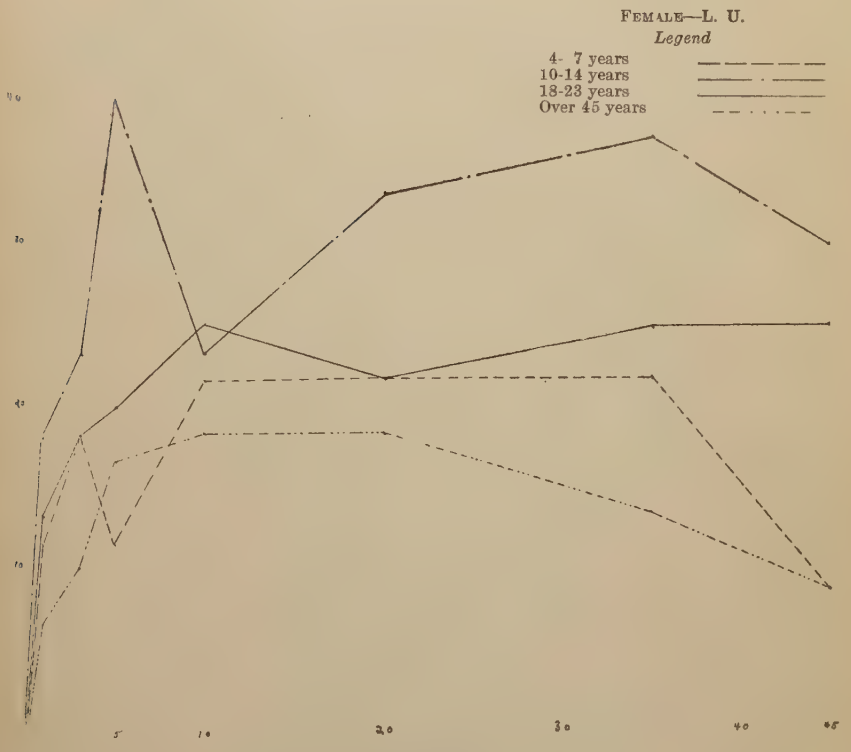

Chart XIV.

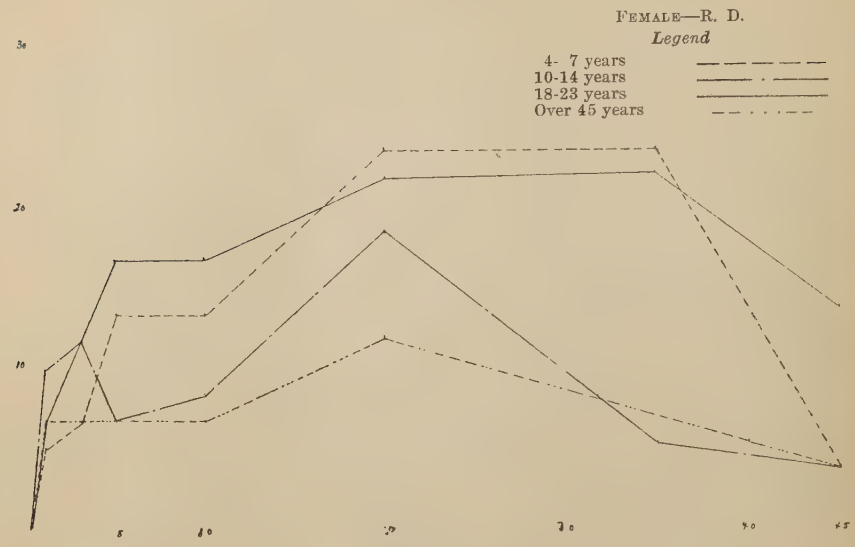

Chart XV.

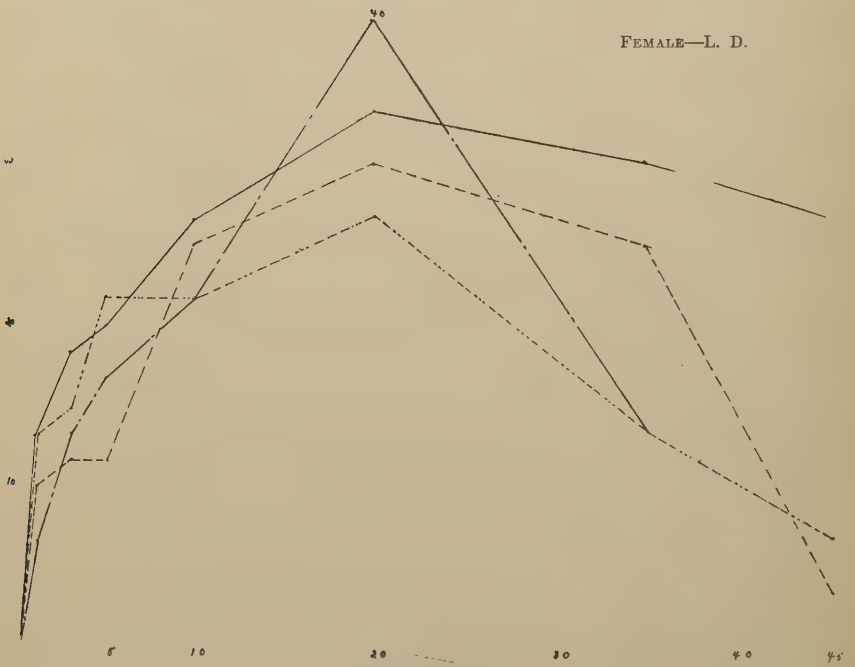

Chart XVI.

VITA.

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Psychologist—Bellevue Hospital, Psychopathic Service 1923; Psychologist, New York Department of Public Welfare, Bureau of Investigation of Mental Cases 1924; Assistant in Physiology—University of California 1925-26; Interne Bellevue Psychopathic Service 1927-28; Assistant Alienist Bellevue Hospital—1928-29; Alienist (Junior) Bellevue Hospital, 1929-30; Psychiatrist—Institute for Juvenile Research 1930.

Member of: Tau Psi Epsilon Honorary Psychological Fraternity; Phi Sigma Honorary Biological Fraternity; American Psychiatric Association; American Orthopsychiatric Association; Royal Medico-Psychological Association (England); Society for Medical Jurisprudence; American Sociological Association; American Institute for Criminal Law and Criminology. Associate, American Psychological Association.